The Chicago Handbook of University Technology Transfer and Academic Entrepreneurship

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Contents

CHAPTER FIVE

Challenges in University Technology Transfer and the Promising Role of Entrepreneurship Education

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Introduction

The purpose of this chapter is to reflect upon the challenges that confront university technology transfer efforts and to consider the role of entrepreneurship education both in addressing these challenges, and as an area in its own right. To begin, we outline the boundary conditions for our reflections, noting the somewhat narrow domain of university technology transfer through start-ups. We then expand upon the general challenges for commercialization of new technologies, focusing especially on resource requirements that are exaggerated in the case of university spin-outs. Finally, we consider the role of entrepreneurship education in addressing these challenges. We propose a number of specific ways in which entrepreneurship education can proceed most effectively while suggesting several important distinctions between entrepreneurship education and technology transfer that, we argue, are important to recognize and maintain.

The Domains and Intersection of University Technology Transfer and Entrepreneurship Education

Any investigation of university technology transfer and entrepreneurship must begin with an acknowledgement that most university tech-

nology transfer does not proceed through start-ups and spin-outs. As illustrated in figure 5.1, annual surveys conducted by the Association of University Technology Managers (AUTM) indicate that established companies, not start-ups, hold the vast majority of licenses to university technologies—a fact that has remained relatively consistent over time. A technology-licensing officer with a major U.S. university shared with us one explanation for the high proportion of established companies among all licensees:

> When I review a new [invention] disclosure and am attempting to figure out if there's a market for it and if we can find a licensee, the natural place to look is the set of companies that have licensed similar things from us in the past. Almost by definition, that means that we're looking first to more established companies, unless the inventor specifically points us to a startup. But even then, we're still going to check with our existing portfolio [companies] and contacts to assess interest, figure out the market value, and so on.

In light of this situation, the heavy emphasis on start-ups, in connection to university technology transfer, may come as a surprise (e.g., Degroof and Roberts 2004; Di Gregorio and Shane 2003; Franklin, Wright, and Lockett 2001; Lerner 2005; Lockett, Wright, and Franklin 2003; Lockett and Wright 2005; Markman et al. 2005; Nerkar and Shane 2003; O'Shea et al. 2005; Siegel, Wright, and Lockett 2007; Smilor, Gibson and Dietrich 1990; Wright, Birley, and Mosley 2004).

Start-ups and large companies cannot be considered simple substitutes for one another in the commercialization of university research, however, for four reasons. First, Tushman and Anderson (1986) and Henderson and Clark (1990) outlined how disruptive technologies and "architectural" innovations require different capabilities and strategies to commercialize than do incremental technologies. In turn, Christensen (1997) proposed that established companies face an "innovator's dilemma" in that they do not wish to erode existing market share by promoting new and disruptive technologies. As a result, they are less likely than start-ups to attempt to commercialize these types of technologies. Insofar as universities are more likely to conduct basic research that leads to disruptive rather than incremental technologies, start-ups may play a crucial and disproportionately active role in commercializing important disruptive technologies. In turn, this role may not be borne out in statistics on volume alone.

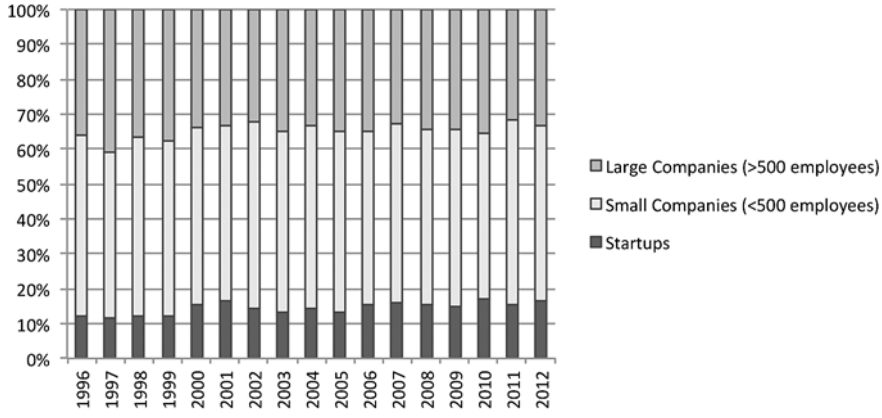

FIGURE 5.1. Percentage of university technology licenses signed with start-ups, small companies, and large companies over time. Source: AUTM 2013.

Second, many universities, especially those that are public, emphasize local or regional impact as part of their mission. Insofar as start-ups are locally based and large companies are not, an emphasis on university technology transfer through start-ups is understandable (Benneworth and Charles 2005; Feldman and Desrochers 2003; Siegel and Phan 2005).

Third, on a related note, it is easier to assess economic impact through start-ups versus large companies. For example, it is straightforward to claim that a license facilitated a new start-up that now employs eight people. It may also be the case that the same license would have permitted a large company located in the same region to add eight employees (or to save eight employees from losing their positions). Absent a detailed understanding of the internal labor market and organization within this large company, however, the case for regional employment and economic impact is more difficult to establish in the large company case.

Finally, as one university administration official shared with us, "Startups are in; big corporations are not. We'd much rather tell community leaders, donors, alumni and others, 'We support startups,' than, 'We support multinationals.'" Thus, positive social affect toward start-ups may explain, in part, the emphasis on start-ups. For all of these reasons, and undoubtedly many more, discussion of start-ups dominates much of the academic literature on university technology transfer, even though start-ups represent a fraction of university technology transfer activities.

Another aspect of our investigation of university technology transfer and entrepreneurship education is that we direct our comments specifically at the "traditional" case of start-ups who sign licenses for university inventions. In so doing, we fully recognize that these formal arrangements fail to capture a great deal of other links between technology transfer and entrepreneurship. For example, Agrawal and Henderson (2002) surveyed faculty in MIT's departments of mechanical and electrical engineering. Their results indicated that patents and licenses account for only 7% of knowledge flows out of these researchers' labs. In an exhaustive study of Stanford's computer music center, which ranks among the most active out-licensors and patentors at Stanford, Nelson (2012) found that licenses captured only about 5% of the organizations developing these technologies for commercial use (as indicated by patent citations). Both Agrawal and Henderson (2002), as well as Nelson (2012), show that far more technology transfer takes place via conference presentations, publications, hiring of recent graduates, consulting, and collaborative research than via development by license-holding university spin-outs.

Finally, as we discuss further in the final section of this chapter, entrepreneurship, in our view, extends far beyond "starting a new company." Following Shane and Venkataraman (2000: 218), we argue that entrepreneurship fundamentally is concerned with "how, by whom, and with what effects opportunities to create future goods and services are discovered, evaluated, and exploited." Thus, entrepreneurship may involve social rather than (or in addition to) commercial aims (e.g., Mair and Marti 2006; Martin and Osberg 2007; Tracey and Phillips 2007) and it may take place within existing organizations alongside start-ups (e.g., Antoncic and Hisrich 2001; Antoncic and Hisrich 2003; Carrier 1993; Pinchot 1985). Clearly, this conceptualization extends the domain of entrepreneurship education beyond the training of students on "how to start a new company" and it signals that university technology transfer efforts represent only a small segment of entrepreneurship education.

Taken together, these parameters indicate that our exploration of the intersection of university technology transfer and entrepreneurship education must be acknowledged as capturing only a small fraction of each of these activities. Nevertheless, given the important role of university spin-outs in innovation and economic growth (Acs, Audretsch, and Feldman 1994; Audretsch, Keilbach, and Lehmann 2006; Audretsch and Stephan 1996; Bania, Eberts, and Fogarty 1993; Hart 2003; Muel-

ler 2006; Wennekers and Thurik 1999) alongside the many difficult challenges with these spin-outs, it is critical to consider the ways in which entrepreneurship education might enhance the effectiveness of these efforts.

A Review of the Resource Challenges for University Spin-outs

As a number of scholars have noted, commercialization of research presents both technology risks and market risks (e.g., Byers, Dorf, and Nelson 2014; Kaplan and Strömberg 2004; Rosenberg 1996; Shepherd, Douglas, and Shanley 2000). Technology risks center on the fundamental question, "Can you build it?" The answer to this question must address issues of reliability, ease of mass production, cost to manufacture, and so on. Market risks, parroting the famous line from the movie *Field of Dreams*, center on the question, "If you build it, will they come?" A strong answer to this question must address whether the market will develop quickly enough, in large enough numbers, with customers willing to pay the necessary sales price, and so on. Both technology and market risks loom very large in the case of research commercialization. Arguably, however, these challenges are not unique to the university case or to the nascent start-up case; any company that attempts to commercialize a new technology faces these same risks. We focus our comments in this section, therefore, on the unique resource requirements that a university spin-out confronts.

The most conspicuous resource in the minds of many entrepreneurs is financial. As the adage goes, "It takes money to make money." In the case of start-ups, financial resources may be necessary to develop a product, attract a team, conduct marketing activities, secure a facility, and perform other basic functions associated with building a company. In this context, practitioners and academic researchers alike focus considerable attention on venture capital as a finance mechanism (Baum and Silverman 2004; Hallen 2008; Jeng and Wells 2000; Kortum and Lerner 2000; Wright, Vohora, and Lockett 2004; Wright et al. 2006). It is worth noting, of course, that only a small percentage of start-ups exhibit the scalability and large market potential to make them good candidates for venture capital and that an even smaller percentage of start-ups ever receive venture capital. For example, Kauffman Firm Survey data indicate that among 3,564 capital injections received by firms in the 2004 survey,

just 26 were in the form of venture capital (less than 1%). Of those firms that survived to 2008, just seven of 1,673 subsequent capital injections (again, less than one percent) were in the form of venture capital (Robb et al. 2010). In other words, venture capital financing is a very rare event among the full suite of start-up financing activities.

Since the Kauffman Firm Survey data include a broad cross section of firms, while university spin-outs typically are science- or technology-based, university spin-outs are more likely than the average start-up to be a match for venture capital financing. Still, recent AUTM data show that just 13% of university spin-outs are VC-funded (AUTM 2013). Thus, venture capital remains a minority player in the financing of university spin-outs.

Some states have attempted to provide funding to university technology spin-outs directly. For example, in 2007 the state of Oregon launched a "University Venture Development Fund," which is funded via a generous tax incentive for private donors and which provides proof-of-concept and translational research grants to university spin-outs (Meyer et al. 2011). Similar programs exist at many other universities and in many other states. As Lerner (2009) highlights, however, these efforts can struggle to reconcile multiple and sometimes-competing goals, such as financial returns, company growth, and regional employment.

A second resource requirement, and one that may be closely tied to financing, is facilities and equipment. Academic researchers have offered considerable attention to science parks, business incubators, and other arrangements that attempt to fill early facilities needs for university technology spin-outs (e.g., Drori and Yue 2009; Ferguson and Olofsson 2004; Lindelöf and Löfsten 2003; Link and Link 2003; Link and Scott 2003; Link and Scott 2005; Monck et al. 1988; Siegel, Westhead, and Wright 2003; Westhead 1997; Westhead and Storey 1994; Westhead, Storey, and Cowling 1995). Science parks and other arrangements may provide assistance beyond facilities, too, including networking opportunities, advice, and basic office services. For some technology start-ups, expensive specialized equipment is another important resource (Bania, Eberts, and Fogarty 1993; Smith 1991). Recognizing this fact, some federal grants stipulate that equipment supplied to one organization be made available to other organizations, including companies. (See, for example, the conditions attached to National Cancer Institute Centers of Cancer Nanotechnology Excellence, as reported in Baker 2006.)

Finally, the most important resource for any start-up is people, in-

cluding potential managers, team members, board members, and advisors (Wright et al. 2007). Here, the academic literature has focused considerable attention on founders, generally ignoring the importance of a deeply skilled and relevant pool of potential employees and advisors. Within this focus on founders, the academic literature has offered special attention to the experiential, psychological, and even biological characteristics associated with the decision to start a company (e.g., Begley and Boyd 1987; Chen, Greene, and Crick 1998; Delmar and Davidsson 2000; Hisrich, Langan-Fox, and Grant 2007; McClelland 1961; Nicolaou et al. 2008; Robinson et al. 1991; Sexton and Bowman 1985; Sexton and Bowman-Upton 1990). One challenge, of course, is that such observations are not readily actionable; they may lead to the conclusion that if a potential entrepreneur does not score above a threshold on a personality quiz, then she should not bother to learn more about entrepreneurship. To preview our remarks on the role of entrepreneurship education, such a perspective fails to recognize the role and purpose of entrepreneurship education, possibly to the detriment of university technology transfer efforts.

Moreover, an emphasis on entrepreneurial characteristics may overshadow other critical features of people and policies. For example, professional investors will readily point to the importance of start-up experience and a longtime horizon for those who wish to engage in entrepreneurship (Byers, Dorf, and Nelson 2014). Saxenian (1994) has noted the importance of employment alternatives in case any one particular start-up fails; if an individual is to pursue a start-up, she needs some assurance that there are other job possibilities in the region given the somewhat high probability of the start-up's failure. Finally, local and regional policies can have an important impact on the availability of people. For example, states that enforce non-compete agreements may experience outward migration of entrepreneurs and inventors, effectively dampening future entrepreneurial activity in the state (Carey 2001; Marx, Strumsky, and Fleming 2009; Samila and Sorenson 2009). The Kauffman Foundation has argued that health care policy has an important effect on entrepreneurship; the loss of employer-tied health insurance can be a disincentive to venture out on one's own (Ortmans 2013).

In considering these different resource requirements, it is critical to recognize that they are all necessary for a university spin-out to meet with success. For example, approaches to university commercialization that only address "gap funding" are almost certain to fail. Similarly, at-

tempts to train CEOs and founders without addressing the larger labor pool of qualified and relevant technical employees are unlikely to succeed. Unless university commercialization efforts via start-ups address *all* of the resource needs outlined above, individual and independent initiatives will have little impact.

This view of basic university spin-out resource requirements—financing, facilities/equipment, and people—grows more complex with the recognition that specific resource needs vary according to specific technologies and markets. Thus, biotechnology, materials, software, and medical-device spin-outs—to name just four examples—require dramatically different sums of money, facilities/equipment, and types of people in order to be successful. (They also differ, of course, in timelines, potential impacts, and other features.) This heterogeneity poses a challenge to university-focused spin-out efforts. Most universities engage in an incredibly wide range of research activities, from biochemistry to materials science to software—and beyond. In turn, attempts to commercialize university research across this wide range of fields and industries must address their very different resource requirements. In most cases, a university or a regional infrastructure simply cannot provide adequate commercialization resources across all of these areas. For example, only a handful of regions in the United States have an extensive labor pool across the full range of industries that university research conducted in that region might impact. In other regions, simply providing general gap funding or entrepreneurship courses for MBAs, as two examples, without addressing these concurrent and diverse resource challenges is unlikely to spur effective commercialization.

Is Entrepreneurship Education the Solution?

As these considerations highlight, commercialization of university research through the creation and successful growth of start-ups is an enormous challenge that hinges on the successful alignment and execution of a variety of resources, activities, goals, and stakeholders. Against this background, entrepreneurship education is a promising means of improving a start-up's viability—though one, as we will argue, that needs to be taken in context and appreciated for its own goals and principles.

Reviewing the considerations in the previous section, it is apparent that entrepreneurship education can have a positive impact upon many

of them. For example, educational activities focused on product design and development, prototyping, technology trends, and creativity can help to answer the question of "can you build it?" More critically, they also can suggest whether it makes sense to pursue development in the first place and how entrepreneurs might "pivot" their original idea (Liedtka and Ogilvie 2011; Ries 2011; Seelig 2011). Similarly, a core component of many entrepreneurship curricula is market analysis, including needs assessment, positioning, segmentation, and customer relationship management (Blank and Dorf 2012; Byers, Dorf, and Nelson 2014). Undoubtedly, informed attention to these considerations can positively influence the response to the question of "if you build it, will they come?" Given the shared concern with these questions among both start-ups and established firms who engage in technology commercialization, it is clear that the positive influence of entrepreneurship education is not limited to university spin-outs, but rather extends to all cases of commercialization (and beyond).

Entrepreneurship education can help to mediate other university spin-out challenges, too. Most notably, entrepreneurship education can aid in the development of managers and team members, raising their awareness of potential pitfalls and providing insight into effective strategies and operational activities (Manimala 2008; Rasmussen and Sørheim 2006). Less directly, to the extent that entrepreneurship education is incorporated broadly into the curricula of all students, not only those who wish to start a university spin-out, it can influence policy decisions and broad public support for entrepreneurship. In turn, enlightened public policies can positively impact university spin-outs.

Entrepreneurship education, however, is not a panacea and it cannot be expected to solve every challenge; while it is an important means of improving the effectiveness of university spin-outs, it is not the solution to their challenges in and of itself (McMullan and Long 1987). Moreover, our own experiences as entrepreneurship educators along with considerable scholarly research suggest that entrepreneurship education is most effective when it takes a broad view of its audience, curriculum, and partners. We elaborate on each of these areas below.

Audience

In most universities, the majority of entrepreneurship courses are offered in business schools (Binks, Starkey, and Mahon 2006; Gwynne 2008; Sol-

omon and Fernald 1991. Entrepreneurship as a discipline and as an approach to value creation, however, extends far beyond BBA and MBA programs (Gibb 2002; Hynes 1996; Katz 2003; Ray 1990). In turn, more progressive universities offer courses across a wide range of departments and schools. In the case of university spin-outs, in particular, it is critical to expand entrepreneurship education to engineering and science departments where most of these technologies originate (Meyer et al. 2011; Phan, Siegel, and Wright 2009; World Economic Forum 2009). In our view, this move involves a true integration of entrepreneurship into the broad curricula, not the piecemeal education of a few select students (Thursby, Fuller, and Thursby 2009). Moreover, a truly multidisciplinary approach, which mimics the reality of early-stage technology start-ups, is critical to reflect in entrepreneurship education efforts. This perspective not only involves teaching engineers, scientists, and others about entrepreneurship from a business school perspective, but also suggests that business students, as one example, should become literate in areas of science and technology, among others (Clark 1998; Keogh and Galloway 2004; Menzies 2004; Penaluna and Penaluna 2008). Such integration of disciplines through the lens of entrepreneurship is certain to yield insights that cannot be gleaned through the maintenance of disciplinary silos (Clarysse, Mosey, and Lambrecht 2009; Hill and Kuhns 1994).

Such integration may require logistical and pragmatic adjustments by universities and by individual schools or departments. For example, it should be easy for students to enroll in courses across departments, without facing outside enrollment caps and other barriers that may hinder interdisciplinary engagement. (In turn, such cross-enrollment may force some schools to revisit internal revenue models that may reinforce school boundaries.) Interdisciplinary integration may also require adjustment or special consideration of academic calendars, as when a university's law school runs on semesters but its engineering school runs on quarters.

Finally, it is important that the audience for entrepreneurship education extend beyond students. Faculty, administrators, staff members, and those in the community at large can all benefit from entrepreneurship education and offerings should be tailored accordingly (Siegel and Phan 2005). Such breadth can also reinforce synergies among different groups, as when a faculty member participates in an entrepreneurship program or seminar and subsequently promotes or reinforces the role of entrepreneurship among his or her students.

Curriculum

In other work (Nelson and Byers 2005) we have argued that technology transfer can enhance the entrepreneurship curriculum. For example, figure 5.2 illustrates educational ties between various entrepreneurship and technology transfer groups at Stanford University. Notably, the Office of Technology Licensing (OTL), pictured on the right-hand side of figure 5.2, has ties to every group. These ties reflect cases in which university invention disclosures proved fertile examples for class projects; OTL personnel taught units on intellectual property and licensing; external relationships with companies that had licensed university technologies yielded guest speakers for a course; and other relationships.

At the same time, and consistent with a broad view on entrepreneurship, entrepreneurship education should not be limited to a focus on technology start-ups, which is often the case, but should instead focus on developing perspectives and skills that can applied in many ways across many settings. Thus, entrepreneurship education is not to be confused with conducting a feasibility study, writing a business plan, or participating in business plan competitions. While such activities can be valuable academic exercises, they can also lead students to confuse endless analysis, number crunching, and polished "suits and slides" with the actual work of starting and managing an organization. Moreover, they may imply that entrepreneurship can be reduced to "picking" an idea and following a prescribed set of steps according to a specific timeline as outlined in a syllabus. Instead, like all curricular efforts, feasibility studies, business plans, and business plan competitions must be placed in context and must first and foremost be approached as educational, not company- or economy-building, activities.

Indeed, emerging evidence indicates that entrepreneurship education should take a variety of forms, including traditional courses, work-study programs, internships, mentoring relationships, workshops, seminars, and all-campus initiatives such as "Entrepreneurship Week," a worldwide event centered on hands-on activities that expose college students and others to creative problem solving and other aspects of entrepreneurship (Fayolle and Gailly 2008; Garavan and O'Cinneide 1994; Pittaway and Cope 2007; Rutger 2008; Wee and Lynda 2004). Within these structures and events, entrepreneurship education might include games, simulations, case studies, feasibility studies, discussion of readings, lectures, interviews, field studies, hands-on exercises, and other activities

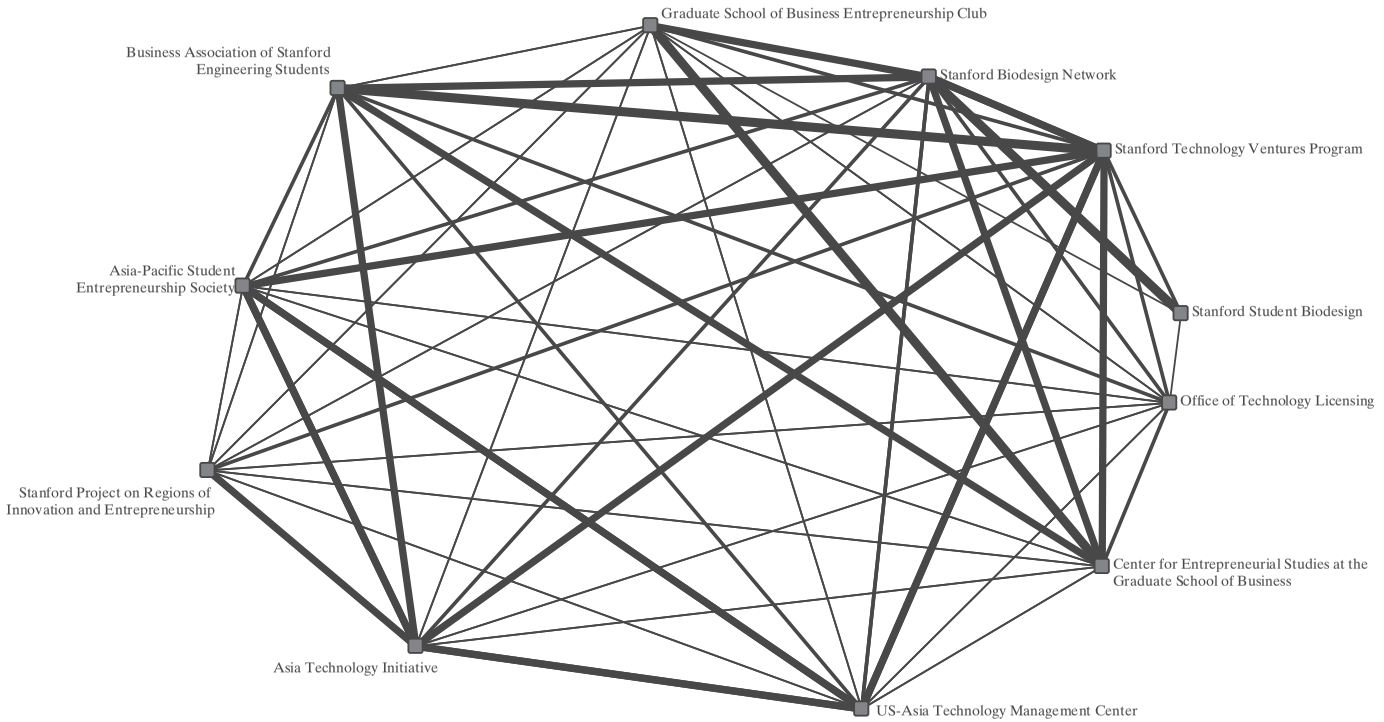

FIGURE 5.2. Educational ties between technology transfer and entrepreneurship groups at Stanford University. Ties indicate responses to the question, "Faculty or staff from your group are involved in teaching students from." Thickness of line indicates frequency on a five point scale from "never" (which has no line) to "nearly always" (which has the thickest line). Image is from Nelson and Byers, 2005.

(Clarysse, Mosey, and Lambrecht 2009; DeTienne and Chandler 2004; Katz 1999; Kuratko 2005; Mustar 2009; Verzat, Byrne, and Fayolle 2009). Such a diversity of offerings permits students to engage with entrepreneurship in different ways and with different levels of commitment, facilitating low-risk experimentation along with content and formats tailored to specific interests (Vesper and McMullan 1988).

In terms of content, entrepreneurship education plays an important role not only in informing individuals how to start a company, but also in teaching them how to manage and grow organizations (Klandt 2004). Mullins and Komisar (2009) offer compelling evidence that most start-ups will switch business plans or even entire industries over the course of their growth. For technology-based start-ups, in particular, such shifts may be the norm rather than the exception (Ries 2011). In the same vein, Collins and Lazier (1995) focus on the unique challenges of managing small- to mid-sized companies, exploring the crucial steps between "launch" and a large stable company. These works and others imply that limiting entrepreneurship education to the point of launch or raising a first round of outside funding may be akin to demonstrating tilling and planting to would-be farmers but neglecting to discuss watering, fertilizing, harvesting, crop rotation, and other equally important topics. Fully executing on this "lifecycle" approach to entrepreneurship education also suggests that entrepreneurship should be fully integrated into other courses that address challenges that typically confront later-stage organizations. A number of universities (e.g., Stanford and MIT), in fact, extend the content and conceptualization of entrepreneurship even further, considering it a leadership training initiative rather than an area focused specifically on starting organizations.

Given the many different fields in which entrepreneurs act, courses and content should also reflect upon, compare, and contrast different settings, rather than attempting to apply a single model to all entrepreneurial endeavors. Thus, as one example, some universities offer special courses on social entrepreneurship, recognizing its unique characteristics (Smith et al. 2008; Tracey and Phillips 2007). In the area of technology commercialization, entrepreneurship courses must be careful to acknowledge the important distinctions between different fields and different types of technologies, again recognizing the significant heterogeneity between cases of university technology spin-outs rather than attempting to treat them equally.

Finally, the impacts of entrepreneurship education must be perceived

as lifelong and not immediately discernible. Even for those students who will start a company, the vast majority are not in a position to be effective leaders immediately upon graduation and they are better served by first gaining relevant experience. Entrepreneurship education may have an immediate impact on their perceptions of the feasibility and desirability of starting an organization (Peterman and Kennedy 2003) and on their skills (Souitaris, Zerbinati, and Al-Laham 2007). But, Kauffman Foundation data show that technology-based company founders rarely are fresh graduates, since the median age is 39 and many founders are much older (Wadhwa, Freeman, and Rissing 2008).

Moreover, many students may never spin out a technology or start an organization. They may still carry entrepreneurial skills and attitudes into existing organizations, however, finding that they lead to enhanced problem solving and development of new initiatives, along with overall increases in job satisfaction and performance (Hindle and Cutting 2002). In fact, the realization on the part of some students that they should *not* start an organization must be regarded as a positive outcome. Still other students may find that the primary role of entrepreneurship education is in better understanding the entrepreneurial process and, thereby, developing more accurate and impactful policies or research agendas (Klandt 2004). These outcomes, too, should be regarded as successes even though they do not involve starting an organization.

Together, these broad perspectives on the role and impacts of entrepreneurship education suggest that university administrators and others should not expect to see the effects of entrepreneurship education quickly nor through simple counts of the number of spin-outs. Diverse goals demand diverse measures.

External Engagement

Finally, entrepreneurship education should not be considered the purview or responsibility of universities alone. Instead, educational institutions, non-profits, firms, and government organizations at all levels should play an active role in developing and supporting educational initiatives. For example, as they develop and execute technology-focused entrepreneurship education activities, universities might partner with existing technology-based firms. Such engagement can increase the resource base and ensure that curricula strike an appropriate balance between academic theory and practice (Collins, Smith, and Hannon 2006;

Kuratko 2005; Roebuck and Brawley 1996). Since the commercialization of university technologies is dependent not only upon actions by universities but also by a number of external stakeholders, engagement of these stakeholders in educational efforts can also build relationships that can be leveraged in commercialization efforts (Todorovic and Sontornpithug 2008). In fact, universities are uniquely positioned to serve as a hub for both innovation and educational activities, drawing together diverse groups across a region and/or industry (Clark 1998; World Economic Forum 2009). Viewed in this way, the efforts surrounding activities such as Startup Weekend (Nager, Nelsen, and Nouyrigat 2012) should be viewed as complementary to internal university efforts.

Reconsidering the Relationship between Entrepreneurship Education and Technology Transfer

As evident in our comments above, many effective practices and approaches in entrepreneurship education can enhance technology transfer efforts, though entrepreneurship education also must be recognized as distinct in its goals, orientation, approach, and audience. Just as the realm of technology transfer extends beyond entrepreneurship, the realm of entrepreneurship involves more than technology transfer initiatives. Table 5.1 highlights the differences between technology transfer and entrepreneurship education along a number of dimensions.

As the table indicates, technology transfer is focused on economic and technological outcomes whereas entrepreneurship education is focused on educational development, relationships, and outcomes. Technology transfer, therefore, maintains a strong commercial orientation, while entrepreneurship education exhibits a more nuanced relationship with commercial goals according to the specific perspective at play. Technology transfer also adheres to a shorter timeline than entrepreneurship education: most licenses for new technologies are signed within a year of disclosure (Elfenbein 2006) and patent terms limit revenues to an absolute maximum of 20 years. Thus, Markman et al. (2005) argue that most university technology transfer offices are risk-averse and focused on short-term cash maximization. By contrast, entrepreneurship education takes a long-term perspective and aims for a lifelong impact.

Assessment of technology transfer and entrepreneurship education also differs. Observers typically evaluate technology transfer according to relatively straightforward metrics such as licenses signed or spin-outs

TABLE 5.1. **Distinctions between university technology transfer and entrepreneurship education (adapted from Nelson and Byers 2005).**

	Technology Transfer	Entrepreneurship Education
Goals and Mission	Commercialize inventions; generate income; contribute to regional economic development; spur Start-Ups	Develop leadership skills; integrate courses and disciplines; provide the foundation for new businesses; forge links between academic and business communities
Commercial Orientation	Significant	Mixed—prevalent in traditional Start-Ups, but less apparent in social entrepreneurship and other non- market-focused entrepreneurship activities
Time Horizon	Short-term	Long-term
Assessment	Inventions commercialized; licenses executed; revenue; Start-Ups; regional employment	Attitudes, behaviors, and capabilities, including creativity, risk-taking, pursuit of opportunities, self-confidence, self-efficacy, and organizational founding
Providers and Constituency	Administrators focused on corporate relations and university intellectual property; faculty and students with inventions that hold commercial potential; licensees and potential licensees, including Start-Ups, small companies, and large companies	Faculty, students, entrepreneurs and other members of the entrepreneurship ecosystem, representing a wide range of activities and disciplines

generated.[1] By contrast, the set of outcomes for entrepreneurship education efforts and, therefore, the assessment of these efforts is very broad. As a result, measurement and assessment of the effects of entrepreneurship education remains an important challenge (Falk and Alberti 2000; Fayolle, Gailly, and Lassas-Clerc 2006; Menzies and Paradi 2003; Peterman and Kennedy 2003).

Finally, the providers and constituencies differ for technology transfer versus entrepreneurship education. Technology transfer engages only those faculty and students with an invention of commercial potential, and it strives to link them with external licensors, primarily serving the interests of large companies (Siegel, Waldman, and Link 2003; Siegel et al. 2004). By contrast, entrepreneurship education engages a much

wider cross section of the university population, and it strives to engage a much broader cross section of external partners.

Together, these many differences signal that while technology transfer and entrepreneurship education may be complementary, they also must be recognized as very different activities. Absent such recognition, entrepreneurship education programs run the risk of missing out on broader opportunities beyond technology transfer or, in the worst case, adopting inappropriate goals, metrics, and timelines that fail to maintain the educational mission of entrepreneurship education as central (Meyer et al. 2011; Nelson and Byers 2005).

Given the idiosyncratic history of many entrepreneurship programs, many educators have not explicitly considered their program's relationship to technology transfer, including the extent to which this orientation implicitly or explicitly affects program offerings, goals, and constituencies. As such, we propose the following set of questions by which one can assess this relationship for a particular university or program:

1. What proportion of entrepreneurship students is within the business school versus outside of it? Is the entrepreneurship "student body" dominated by a single discipline?
2. Do we offer entrepreneurship courses beyond those courses that train for the commercialization of technologies? To what extent does the entrepreneurship curriculum emphasize topics beyond technology commercialization?
3. Do we offer a wide range of courses in a wide range of formats (e.g., seminars, speaker series, project-based courses, work-study programs, etc.)?
4. Do our entrepreneurship instructors represent a wide range of backgrounds and experiences? Do we look for instructional talent beyond those individuals whose experience is based on commercialization of technologies?
5. How many different units across our university are actively engaged in entrepreneurship education efforts? What is the extent of their engagement and how balanced is it across units?
6. What are the perceptions of the average student on campus about entrepreneurship? How do these perceptions align with our program's mission and goals?
7. What expectations do senior administrators, alumni, funders, and the gen-

eral public have regarding our entrepreneurship efforts? To what extent is their focus on commercialization versus education?

8. What are the sources of funding for our entrepreneurship education efforts? Are funding sources (including appropriations and grants) independent of technology commercialization links and programs?
9. What timeline do students, faculty, and others attach to entrepreneurship? Do they take a long-term perspective?
10. What evidence do we have of the success of our entrepreneurship education efforts? What metrics do we implicitly or explicitly emphasize when considering our entrepreneurship program's success? How important is commercial impact in assessing our entrepreneurship center? What metrics or statistics do we highlight when describing our program?

There is no answer key for these questions. Rather, they are intended to highlight implicit assumptions about the role of entrepreneurship education and its relationship to technology transfer. Those respondents whose answers heavily emphasize technology transfer may find that their entrepreneurship education efforts could be even more impactful by moving beyond this particular conceptualization. Conversely, those respondents who find too little engagement with technology transfer may find that their entrepreneurship education efforts are failing to address this important area and to take advantage of complementarities with it.

More generally, the fact that entrepreneurship education and technology transfer are complementary yet also distinct highlights a crucial challenge: how to facilitate synergies between the activities while not allowing one to co-opt the other. In other work, we have proposed that the concept of "organizational modularity" offers a promising model (Nelson and Byers 2005). In a seminal article, Weick (1976) argued that when an organization pursues multiple goals that may conflict, its formal structure may be only "loosely" integrated. Adkison (1979) offered an early application of Weick's concept through her study of the Kansas Public School System. She found that "loose coupling" between participants allowed them to pursue unique roles and responsibilities while avoiding conflict. Tushman and O'Reilly (2004) drew upon these same ideas in developing their concept of "ambidextrous" organization. In their view, organizations that attempt to apply a single model or perspective to all subunits realize poor outcomes compared to those organizations that recognize and facilitate differences. (See also Martin and Eisenhardt 2003.)

At the same time, organizations profit from ensuring that these units coordinate activities and initiatives where synergies exist, as when entrepreneurship education and technology transfer are mutually beneficial. This coordination depends first and foremost upon awareness among various members about the activities of others. For example, Tushman and O'Reilly (2004) highlighted the benefits from integrated top management teams when units are independent, since this integration facilitates awareness and coordination across the independent units. In a study of twelve cross-business synergy initiatives, Martin and Eisenhardt (2003) found that high-performing initiatives originated in the business units, not at the corporate level, and that high-performing initiatives had an "engaged multi-business team decision process," rather than a top-down corporate decision process. Similarly, Tsai's (2002) investigation of a large diversified organization revealed that formal hierarchical structure had a negative effect on knowledge sharing between units, while informal lateral relations had a positive effect.

Together, these studies, and others, suggest that awareness and cooperation function best when allowed to emerge from the bottom up. For example, in a comparison of university technology transfer performance in the U.S. versus Sweden, Goldfarb and Henrekson (2003) found that much of the higher performance in the U.S. was attributable to its bottom-up approach versus Sweden's top-down approach. Similarly, those universities that are attempting to make the most of relationships between entrepreneurship education and technology transfer must, somewhat ironically, avoid planning these relationships in a centralized fashion. Instead, relations should emerge organically, with administrators providing some resources and facilitating connections, but not driving policies and initiatives. At the same time, individual participants in the entrepreneurship and technology transfer ecosystems must take pains to ensure that their bottom-up efforts do not simply include the "usual suspects" and reinforce existing relationships; the nurturing and growth of entrepreneurship education and technology transfer demand the constant infusion of new ideas, participants, and programs.

Summary and Conclusion

Both entrepreneurship education and university technology transfer have witnessed dramatic increases over the past two decades (AUTM

2013; Charney and Libecap 2000; Katz 2003; Mowery et al. 2001; Solomon, Duffy, and Tarabishy 2002; Vesper and Gartner 1997). While there are a number of dimensions to each of these areas, their simultaneous growth reflects, in part, the many complementarities between them. On a fundamental level, the commercialization of university technologies requires vision, leadership, persistence, imagination, and the ability to assemble critical resources, including financial and human capital. Entrepreneurship education strives to develop these very skills and capabilities. As a result, the close relationship between these areas should not come as a surprise.

Our review of the entrepreneurship education and technology transfer literatures highlighted a number of ways in which the two fields can inform one another and in which, on a pragmatic level, programs and resources may be shared and integrated. Specifically, we discussed how broad perspectives on both the audience and curriculum for entrepreneurship education, along with deep engagement of external partners, can enhance technology commercialization and education efforts overall. For those entrepreneurship programs that have not engaged with university technology transfer personnel and programs, such engagement represents a straightforward and effective means of extending the impact and "real world" engagement of their efforts.

At the same time, we described a number of dimensions along which entrepreneurship education and technology transfer differ. A major challenge lies in ensuring that these differences are respected and maintained. For example, a program director interviewed by Meyer et al. (2011: 189) acknowledged that

> many programs similar to ours started out with education as the central goal (as we did), but through mission creep, educational goals gave way to trying to maximize revenue, deals, IP licenses, business competition prizes, and other metrics. If we want to avoid pitfalls that have diverted other programs, we must never lose sight of the importance of delivering value to all of our students.

The siren song of start-ups, management titles, prize money, and investors can be alluring to students, faculty, and administrators alike. Focusing entrepreneurship education efforts primarily upon technology commercialization efforts, however, sacrifices the incredible breadth of the field for a very high-risk low-probability outcome with a limited ed-

ucational impact. By contrast, by *not* focusing primarily on technology transfer and instead ensuring that entrepreneurship education maintains a wide set of goals and a diverse audience, universities can effectively strengthen their entrepreneurial ecosystem—yielding, ironically, even greater long-term benefits for technology transfer.

Note

1. Siegel, Waldman, and Link (2003) note that other important aspects of technology transfer offices, such as organizational practices, are not amenable to quantification and, therefore, are often overlooked.

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